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One Assignment, Two Courses, Multiple Skills: A Major Engineering Assignment with Social, Political and Ethical Dimensions

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Abstract

This paper discusses a major interdisciplinary assignment that spans two first year courses in the School of Sustainable Energy Engineering (SEE) at Simon Fraser University, Canada. The Persuasive Research Paper asks students to draw on ideas from multiple scholarly disciplines and fields of practice to argue a social, political, or ethical position in relation to a technical, engineering, or scientific topic. It is a combined assignment across two SEE courses, *Energy, Society and Environment*, and *Process, Form and Convention in Professional Genres*, and is intended to prepare students for future courses in the SEE program, their co-op placements, and their professional responsibilities as an engineer. Students are required to research and write a paper exploring opposing positions related to an area of controversy chosen from a list of topics supplied by the instructors. The assignment consists of four components, each of which involves a draft and final version, and peer reviews. Two preliminary assignments help students to plan their research, frame the position they will take on their topic, and conduct scholarly research. These prepare students for the other two components, a technical analysis and the final paper. For the peer review, students are grouped into threes and each person uses established criteria to review their group members' papers using the ACE (Analytical, Constructive and Empowering) model of feedback. Students learn the skills of finding and using scholarly resources, and using persuasive arguments that draw on reliable sources and evidence. Also, throughout the assignment, students are practicing leadership skills, learning written and oral communication skills, and gaining a breadth of knowledge about energy, sustainability and society.

1 Introduction and Background

Systems thinking, critical thinking, complexity, and interdisciplinarity are important components of education for sustainable development (Cotton & Winter, 2010; Neal & Langley, 2012; UBC, 2018). To integrate these into an already crowded engineering curriculum, two faculty members in the School of Sustainable Energy Engineering created a major interdisciplinary assignment that spanned across two first year courses. One of the courses is on writing and communications entitled, *Process, Form and Convention in Professional Genres* (SEE 101W), and the other is an introduction to sustainability and energy, *Energy, Society and Environment* (SEE 110). Two of the authors of this paper, Vivian Neal and Taco Niet, are the faculty members who teach these courses, and the third author, Daina Baker, was the teaching assistant for both courses in Fall 2019. This paper describes the motivation for the assignment, the assignment structure and delivery, the perspectives of the instructional team, and an assessment of its success.

The School of Sustainable Energy Engineering at Simon Fraser University welcomed its first students in September 2019. The first of its kind in Western Canada, the program is housed in a new state of the art facility in which students interact with, and learn from, the sustainable energy features of the building. (For details about the SEE program, see Neal *et al.*, 2018.) Consistent with current literature about education for sustainable development (Goldberg & Somerville, 2016; Sheppard, 2009; Winter, Cotton, Grant & Hopkinson, 2015), the program is interdisciplinary, and emphasises experiential learning and communication skills. In addition, it exposes students to industrial paid work experiences through the co-operative education program, as well as community driven projects and collaborative research opportunities.

2 The Two Courses

Process, Form and Convention in Professional Genres is in some ways a conventional first year engineering communications course, covering technical writing, communicating persuasively, giving presentations, and working in a team. Its differentiating characteristic is how pedagogies consistent with education for sustainable development have driven the course design. Students are active participants in their own learning, learning from each other in collaborative learning activities. They work in groups and individually, engaging in critical thinking and reflection exercises. A notable example is that most assignments are peer reviewed by fellow students, to improve communication skills, develop empathy, and clarify ideas about sustainability. In addition to the major combined assignment detailed in this paper, students research and write two short papers related to the United Nations Sustainable Development Goals; this exercise provides students with some foundational understanding of sustainability and sustainable development.

Energy, Society and Environment covers a variety of topics related to energy and sustainability, and the social, political and environmental implications of the materials, water and energy flows required to support human society. Both local environmental and sustainability issues, and global challenges in sustainable development are explored to provide students context for their future careers in sustainable energy engineering. Typical learning activities include students calculating their energy footprint compared to the average energy footprint of other societies around the globe, and creating energy chains from source to end use with calculating their material and energy flows. In addition to gaining technical knowledge, students interact and learn from each other using various teaching structures such as 25/10 crowd sourcing (Liberating Structures, 2020) to obtain topics they would like to learn about, think-pair-share discussions of different topics, and open classroom discussions about the responsibility of an engineer in society.

For Fall 2019, 46 students were enrolled in total, with 36 enrolled in both courses and 10 enrolled in only one or the other.

3 Combined Assignment – Persuasive Research Paper

For the Persuasive Research Paper students argue for a social, political, or ethical position in relation to a technical, engineering, or scientific topic. Students are encouraged to select their topic from a provided list or chose their own in consultation with the course instructors. Rather than simply describing a technology or issue, students are required to explore opposing positions of a controversy and then adopt a position and argue in favour of that position using evidence and persuasive strategies. Through this research and writing process they analyze and synthesize some of the complexities of real-world sustainability issues such as the interlinked problems of energy consumption, climate change, resilient governance, loss of biodiversity, and poverty. They must approach this work with an interdisciplinary lens and systems-level thinking because such issues cannot be sufficiently understood in isolation.

The length of the final paper was 2500-3000 words for students taking both course and 1700-2000 words for students taking only of the courses; all other criteria for the Persuasive Research Paper were the same for both groups.

3.1 Assignment Components

The assignment, worth 40% of the marks in SEE 110 and 30% in SEE 101W is a major term activity for the students and consists of several components as shown in Table 1. These components help ensure that students are working on their topics throughout the term, where each component includes a draft, ACE peer feedback on that draft, and a final submission.

Table 1: Assignment Weighting

Assignment Component	Grading Weight	
	SEE 101W	SEE 110
Planning and Strategies	5%	5%
Annotated Outline and Sources	5%	5%
Preliminary Technical Analysis	Not Applicable	10%
Persuasive Research Paper	20%	20%
TOTAL	30%	40%

The *Planning and Strategies* assignment helps students to define their topic and plan their paper. At 500 words, it includes their research question, a description of the purpose, audience and message of the paper, at least 4 “mini” questions that will guide their research, and a description of the writing process they plan to use.

Mini questions are sub-topics that need to be researched in order for the student to complete the main research question. In SEE 101W, students practice creating “mini” questions through a series of exercises. In one activity, the instructor writes a series of research questions on the white boards around the room and students are given sticky notes on which they pose mini questions about at least one of the questions on the boards. They then post their notes on the boards, review the mini questions of other students, and collectively group them by themes. This helps students develop critical thinking skills, research skills,

writing skills, and empathy, where they are physically moving around the room, in a low-stakes atmosphere of sharing their work and learning from each other.

The *Annotated Outline and Sources* assignment consists of an introductory paragraph to help students formulate a compelling thesis, and an annotated reference list to help students identify scholarly sources and reflect on the utility of each source. In SEE 110, students keep a research journal for which they read two or three articles each week, summarize them, and describe how each relates to their topic. Feedback from the instructor on these journals guides students towards appropriate reference sources.

For the *Preliminary Technical Analysis*, which is submitted in only SEE 110, students must provide the technical reasoning for taking their position, supported by calculations and/or references to technical papers or sources. The analysis shows how the evidence from the literature, and/or students' calculations, supports their position.

The final component is the *Persuasive Research Paper* itself which relies on, and incorporates, the first three components. Through the preliminary assignments, students have already completed the planning and research before they start writing their final paper. Each component builds student competence and allows them to develop their skills and gather information for the final research paper.

3.2 Peer Reviews, ACE Feedback, and Polished Drafts

For each assignment component, students produce a polished draft, and review the papers of two classmates, before submitting their final version for grading. In addition, the teaching assistant provides formative feedback on the polished draft of the Persuasive Research Paper to ensure students receive consistent feedback. Note that for the three preliminary assignments, the teaching assistant does not review the drafts.

To set up the peer reviews, students are randomly assigned to groups of three or four at the beginning of the course. In peer review sessions students use the Analytical, Constructive and Empowering (ACE) model of feedback: *analytical* in that comments will have a good depth of analysis about the paper, *constructive* in the sense that it helps the author understand the issues as well as how the issues can be addressed, and *empowering* to inspire confidence in the author's ability to improve their writing.

For the first three assignment components, the peer reviews are conducted during tutorial sessions and the peer review process is overseen by the teaching assistant. However, for the draft of the final paper, the peer review is initially conducted through the electronic exchange of papers, using the markup features of MS Word. Students then spend time in class discussing the written peer feedback within their groups.

4 Results and Observations

Overall, the student and instructor observations indicate that the combined Persuasive Research Paper assignment in SEE 110 and SEE 101W is a worthy activity for the students. Instructors and the teaching assistant found that the combined assignment helped students developed multiple skills, but also noted some challenges that need to be addressed for future offerings.

4.1 *Multiple Skills*

SEE 110 and SEE 101W provide a strong foundation for students' future studies and co-operative education semesters, and set the stage for their future practice as professional engineers. As such, exposure to a variety of professional and scholarly skills, approaches to knowledge acquisition, and collegial communication are vitally important (Sheppard, 2009).

The Persuasive Research Paper helps students learn the skills of finding and using scholarly resources, using persuasive arguments that draw on reliable evidence, and developing critical thinking and writing skills. Through lectures, readings, and practice, they learn to paraphrase and summarize concepts from source material, learn proper citation and referencing procedures and styles, and how to create a persuasive argument. Additionally, students delve deeply into a topic of their choosing that is aligned with their interests and are therefore motivated to invest the time and energy to learn and engage, enhancing their breadth of knowledge about energy, the environment, sustainability and society. Through giving and receiving peer feedback, students not only improve their own written and oral communication skills, but help enhance the skills of their peers.

Overall, the Persuasive Research Paper helps students develop a variety of valuable skills and abilities including:

- Analytical skills through analysing and using set criteria to give feedback
- Knowledge literacy through engaging with the scholarly literature and identifying what constitutes reliable and less reliable sources
- Written and oral communication skills through research-informed discussions
- Appreciation of the interdisciplinary and complex nature of sustainability challenges
- Systems-level thinking, and
- Collaboration and group work skills, and empathy for their fellow students.

Most of these skills are identified by Engineers Canada as required Graduate Attributes; future work on measuring progress towards these Graduate Attributes will be incorporated in the courses in future iterations.

4.2 *Reflections of the Instructional Team*

Table 2 provides some reflections from the instructional team on their experiences. In general, the instructors observed that the assignment was a success and intend to continue the combined assignment next year with some minor modifications.

Table 2. Reflections of the Instructional Team

Taco Niet, Instructor SEE 110
<ul style="list-style-type: none">• Having a combined assignment in SEE 110 and SEE 101W allowed for a more in-depth paper than students would have been able to write if two separate assignments were required in the two courses. I think this provided students with a valuable learning experience and I am excited about enhancing this experience even further for the next iteration of the course.

- One challenge I experienced in SEE 110 is that I did not anticipate the level of student understanding of technical concepts related to energy. Students' lack of some basic concepts made it more challenging for them to take a technical position on their topics. I look forward to addressing some of these basic gaps in knowledge in the first part of SEE 110 next year so students are better prepared to take a persuasive position and support it.

Vivian Neal, Instructor SEE 101W

- One of the challenges that I didn't anticipate is that the quality of polished drafts was inconsistent. This affected the depth and usefulness of the peer feedback in some groups. That is, when a student brought in a very rough draft, their peers could not provide constructive feedback. In the future, we will give a very small mark for the drafts (about 10% of the revised submissions) to encourage more polished work for the peer reviews.
- I believe that *empathy* and *empowerment* are central to our core beliefs in ourselves, our self-efficacy, and our ability to contribute and interact as professionals. The peer review exercises rely on these qualities to be present in the classroom, established by the leadership of the instructional team. We are very lucky that the instructional team was able to establish a classroom atmosphere and culture that was supportive and safe.

Daina Baker, Teaching Assistant SEE 110 & SEE 101W

- It was remarkable to see students' passion for the topics they were researching and writing about, and excited about making a sustainable world. We are equipping individuals with the tools to realize this future.
- The peer review process was successful in providing students with a chance to interact with students they might not otherwise speak with. The exercise gave students practice in developing their own arguments as well as the arguments of their peers.
- Students seemed to struggle in areas that required scientific background. They sometimes did not make full use of, or misinterpreted, information and data, and therefore drew erroneous conclusions or merely presented information without meaningful analysis.

5 Challenges and Successes

For the most part, students engaged well with the assignment and were enthusiastic about being able to investigate a topic of their choosing. Several students commented that they much prefer to investigate and write about sustainable energy topics than the topics from their English courses in secondary school. Most students were able to write a persuasive research paper that effectively argued for a specific position on a topic, including identifying reliable data sources, referencing sources effectively, and using Zotero (a reference management system) to keep them organized.

Regarding challenges, most students were not clear on how to technically argue for a position as required by engineers, versus making an emotional or rhetorical argument. Most first year students have little technical background. Other challenges include:

- Confusion about which course the assignment was for, since much of the assignment related activity was in SEE 101W only; the instructors will address this in future iterations of the assignment.
- Bringing in minimal drafts for the peer review sessions. This impacted the quality of learning since students didn't have an opportunity to practice giving feedback and authors didn't receive constructive feedback on a draft.
- When sourcing material, students successfully focussed on peer reviewed articles, but often didn't understand the subtleties of what makes a good reference.

5.1 Notes About Future Iterations of the Assignment

The first execution of the assignment went fairly smoothly, but some revisions will be made for future iterations:

- Incorporate additional issues in the list of potential topics based on recent discussions with the staff of the local municipal sustainability office.
- Add more guidance to SEE 110 about the technical analysis, and adjust the weight of the Preliminary Technical Analysis from 10% to 5%.
- Deduct marks if drafts are not polished, to ensure the peer review sessions run smoothly.
- Require students to submit a reflection of their preliminary assignments with their final paper, including how their mini questions informed their research process, and how their original outline changed as they developed their ideas.
- Revise the session about referencing to help students understand the subtleties of good referencing, especially the reliability of sources from peer reviewed, to government and institutional, to Wikipedia, to random website.

6 Conclusion

The combined Persuasive Research Paper assignment offers first year Sustainable Energy Engineering students in SEE 110 and SEE 101W the opportunity to grapple with some of the complexities presented by real-world sustainability issues and technologies. When they argue for a particular position, supported by evidence from the scholarly literature, they necessarily must approach the problem with an interdisciplinary lens and systems-level thinking. This experience establishes the attributes and skills to approach their future studies and professional activities with an appreciation of the vagaries and interdisciplinary nature of sustainability challenges. In future iterations of this assignment, the authors plan to make several minor, but important, adjustments. The instructors are continuing to dialogue with local city staff about potential projects and topics for this combined assignment with the hope of making the exercise even more meaningful for students.

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